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April 7, 1992

To: Norman Smith
From: Samuel Milham Jr. M.D.
Subject: Answers to the four questions posed by Mr. Mc Curdy in Environental Health Letter, March 18, 1992, P. 3

1. The ANSI standard in the U.S. is not nearly as conservative as those set in Russia, Eastern Europe, Australia and elsewhere. The U.S. standard is based solely on tissue heating. Scientists setting these more restrictive standards elsewhere must believe that athermal effects exist, are potentially harmful, and set their standards accordingly.

2. Until dose-based morbidity and mortality studies are done in human populations, all RF/MW standards will be arbitrary. Until an exposure-based standard can be set, I feel that an ALARA approach is most reasonable. In the case of siting new antennas, I feel that standards should require that people in the closest residences should not have their RF/MW exposure levels increased.

3. The approach in the EIR seems adequate given the current state of knowledge in the field. However, where doubt about human health impacts exists, any error in standard setting should be conservative. This standard was daveloped before most of the athermal effects were known. Since it is designed only to protect against tissue heating, it is not a conservative standard.

4. Dr. Guy is a respected and founding member of the Bioelectromagnetics Society. He simply does not believe that athermal levels of RF/MW exposure can cause human health problems. Interestingly, work in his own lab suggests that pulsed RF at athermal levels may cause cancer in rats.

My own study of amateur radio licensees who are exposed to both ELF and RF fields showed increased mortality from certain cancers. This, plus the other occupational and residential epidemiologic studies in the literature lead me to believe that exposure standards based on thermal injury only, need lowering.

Exhibit 9

FROM THE FIELD

Clippings from All Over

"The scientist can afford to be skeptical much longer than the person concerned with protecting public health."

—Dr. Keith Baverstock, co-coordinator of the World Health Organization's International Thyroid Project, quoted by Michael Balter in "Children Become the First Victims of Fallout," *Science*, p.360, April 19, 1996

"If there was a health effect from cell phones, because of their popularity it would be a major public health concern."

—Dr. Arthur (Bill) Guy of Wireless Technology Research (WTR), quoted by Tom Paulson in "Cell Phones Are Found To Disturb Pacemakers," *Seattle Post-Intelligencer*, p.A12, May 17, 1996

"The [cancer] research project is really nonexistent. There's nothing there. The emperor has no clothes."

—Ronald Peterson, non-ionizing radiation protection manager at Lucent Technologies Inc. in Murray Hill, NJ, quoted by Jeffrey Silva in "True Goals of WTR Questioned by Industry," *Radio Communications Report (RCR)*, p.33, May 6, 1996 (see p.14)

[Craig McCaw] has difficulty absorbing lengthy written documents and usually avoids them. That leaves time for him to do what he prefers anyway, which is to think and to stand back and take in the big picture.

—Andrew Kupfer, "Craig McCaw Sees an Internet in the Sky," *Fortune*, p.64, May 27, 1996

The Air Force has demonstrated a capability of countering air-defense systems by damaging their components through the use of "extremely" high-power microwaves, according to Secretary of Defense Perry's recently released 1996 Annual Report to the President and Congress. The report also reveals "there are similar programs for protection of land vehicles and ships."

—Gerald Green, "Air-Defense Countermeasures Demonstrated Using Extremely High-Power Microwaves," *Journal of Electronic Defense*, p.15, May 1996

Melatonin, the hormone of the pineal gland, is currently the subject of much ill-informed publicity and speculation in the entertainment media worldwide. Several books on the subject have made grossly exaggerated claims for its value, portraying it as a panacea and as an "anti-aging" treatment. These claims are distortions of current knowledge of the physiological functions of melatonin and its therapeutic potential.

—Dr. J. Arendt, professor of endocrinology at the University of Surrey in Guildford, U.K., and author of *Melatonin and the Mammalian Pineal Gland*, in an editorial, "Melatonin: Claims Made in the Popular Media Are Mostly Nonsense," *British Medical Journal* (U.K.), p.1242, May 18, 1996

"There's no doubt the controversy has exploded in the last two years. Eight or ten years ago people never commented. You just sold the houses under the power lines and they may have had a little bit of a grizzle about it. Now people are much more informed and ask themselves questions like: How are we going to be compensated? How will we be able to sell out? Certainly, none of the prudent or wise or informed will buy them. Women with children are scared. They don't want them playing in the backyard."

—Gerald Foley, a real estate agent in Keilor, Australia, who says that 90% of home buyers reject houses near power lines, quoted by Veronica Ridge in "High Voltage Living," *The Age* (Melbourne, Australia), p.3, April 17, 1996

Letters to the Editor

EMI to Medical Devices from Cellular Antennas

March 22, 1996

To the Editor:

We would like to make a comment on your article "California PUC Advises Against Cellular Antennas near Schools and Hospitals" [see *MWN*, N/D95]. In particular, we would like to comment on the issue of siting cellular antennas on or near hospitals.

The hospital administrations, medical boards and biomedical engineering departments are generally consulted in the siting of antennas and these people are surely in the best position to judge any health effects.

There is, however, one issue that should be considered when siting cellular antennas on or near hospitals and that involves the electromagnetic interference (EMI) to medical electrical equipment.

The U.S. Food and Drug Administration (FDA) issued a voluntary standard[1] specifying that medical electrical equipment should be immune from EMI in fields up to 7 V/m within the frequency range 450 to 1000 MHz. The International Electrotechnical Commission (IEC) has published a standard on electromagnetic compatibility for medical electrical equipment[2] in which it states that an immunity level of 3 V/m shall apply for the frequency range 26 to 1000 MHz. However, it is stated in this standard that the 3 V/m immunity level may be inappropriate because the physiological signals measured may be substantially below those induced by a field strength of 3 V/m.

In recognition of the fact that safety-of-life medical electrical equipment requires a higher level of immunity, the IEC has issued a draft standard for infusion pumps and controllers,[3] which states that an immunity level of 10 V/m shall apply for the frequency range 26 to 1000 MHz.

We have conducted extensive testing of the potential of cellular telephones to interfere with the operation of medical electrical equipment and consulted with manufacturers of that equipment. Our conclusion is that medical electrical equipment should not be exposed to levels above 1 V/m from mobile radio installations.

We ensure that protection is provided by, first, designing our antenna installations with a rule that no area that is likely to have sensitive medical electrical equipment will have a field strength of greater than 1 V/m. This can be achieved by transmit power control and suitable antenna design and positioning. Second, we confirm that the 1 V/m criterion is adhered to through measurement at the site.

Typical measured field strengths in hospital wards range from 6.7-67.5 mV/m (equivalent power densities of 0.012-1.2 nW/cm²) per digital carrier or analog channel leading to total field strengths in the range 13.4-580 mV/m (0.048-89 nW/cm²). The total field strength depends on the number of digital carriers (typically 2 to 4 per sector) or analog channels (typically 32 per sector) present, and an enhancement factor of 3 dB (numerical factor of 1.4 for field strengths and 2 for power densities) has been included to account for possible reflections.

Yours sincerely,

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BEFORE THE

FEDERAL COMMUNICATIONS COMMISSION

WASHINGTON, DC 20554

In the Matter of	)
	)
Section 68.4 of the Commission's Rules	)
Hearing Aid-Compatible Telephones	)

PETITION FOR RULE MAKING

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EMC CONSIDERATIONS FOR DIGITAL CELLULAR RADIO AND HEARING AIDS

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Abstract

This paper describes the compatibility problem between digital cellular radio and hearing aids. Research has shown that any radio system using time division multiple access could regularly interfere with hearing aids. This problem may be reduced by constraints on the cellular system implementation although an increase in hearing aid immunity to such signals is required if this problem is to dealt with effectively. It is hoped that COST 219 may be able to bring such changes about. This information was presented to a meeting of COST 219 on the 16th June 1992 in Dublin.

1. Introduction

The aim of this paper is to describe the potential compatibility problem between digital cellular radio systems and hearing aids. In doing so it is hoped that action may be taken to improve the current situation.

The compatibility problem stems from any system where time division is used to multiplex many users onto a single RF carrier (Time Division Multiple Access - TDMA). This process results in the carrier being turned on and off many times. If the frequency at which this turning on and off occurs is in the audio frequency band then simply designed audio devices, such as hearing aids, can demodulate the RF envelope and produce an annoying 'buzzing' sound. With careful design, these problems can be removed through greater immunity to such signals.

It should be noted that this is an issue for any TDMA system when close to any audio apparatus. However, studies have shown that hearing aids are particularly susceptible and more likely to be close to portable telephones.

This paper therefore covers the standards bodies involved in EMC issues, the initial EMC work, studies carried out at BT Laboratories, highlights possible solutions and then makes some final recommendations.

2. ETSI Standards

This issue has been highlighted through the work of organisations participating in the ETSI standards bodies. On the digital cellular radio side, the sub-technical committee SMG2 has been driving the work forward. This body is charged with the radio aspects of the pan-European digital cellular radio system - GSM. Other ETSI bodies involved in EMC issues are sub-technical committees RES9 and EE4. RES9 are concerned with EMC standards for radio equipment and EE4 in EMC standards for all other telecommunications equipment.

3. Initial EMC Testing

The initial studies of the interference potential of TDMA transmitters was conducted back in 1989 by BT Laboratories, the UK DTI, CSELT, Racal Research and others. At that stage the studies were concerned with hearing aids, personal tape players, domestic audio equipment, TV equipment and cardiac pace makers. These studies resulted in the following findings :-

- No interference to cardiac pace makers
- Slight interference to domestic audio equipment
- Significant interference to body worn audio equipment

4. BT Laboratories Hearing Aid Testing

The work carried out at BTL can be split into 2 areas :-

- Immunity testing
- Interference modelling

4.1 Immunity Testing

A number of hearing impaired volunteers from BTL were asked to take part in a laboratory test. The test consisted of an anechoic chamber (no RF reflections) in which an antenna was transmitting a test signal similar to that radiated by a GSM mobile telephone. The subject was then asked to walk towards the antenna and note the level of perceived interference at various distances. Having previously calibrated the chamber for field strength (in Volts per metre - V/m) the critical field strength could be determined.

The test equipment used to create the transmitted signal allowed the following parameters to be varied :-

- Modulating waveform
- Duty cycle
- Transmit pulse transition time
- Repetition rate
- Carrier suppression
- Carrier frequency

The results of this laboratory investigation showed that the mechanism causing the interference was non-linear devices in the hearing aids demodulating the 100% amplitude modulated square wave of the RF envelope. Since the frame repetition rate is in the audible frequency band the demodulated products are audible. The critical field strength is around 4 V/m for perceptible, annoying interference.

However, what does this mean ? Is this a problem or not ? In order to answer these questions, a modelling exercise was undertaken.

4.2 Interference Modelling

The object of the modelling exercise is to determine, given the 4 V/m critical field strength, what is the probability of a hearing aid user experiencing interference in a typical cellular system ?

Firstly, we must determine the number of active mobiles and their transmit powers. This is done using a typical cell layout to give the maximum number of users at any one time and then a simple link budget is used to determine the transmit powers.

From the transmit powers, we can determine what area around each transmitter will experience a field strength of 4 V/m or greater. If we know the number of mobiles transmitting we can find the total affected area. This is the total area in which a hearing aid user would experience interference.

Given the total area of the cell layout under consideration, we can calculate the ratio of the affected area to the total area. This gives the probability of interference.

If we also know the number and duration of the cellular telephone calls made, we can determine the time between bursts of interference and the duration of these bursts.

This modelling exercise was conducted for the following scenarios :-

- Daily commuter from rural area into city
- Person working and living in city
- Retired person shopping in city

If, for example, we take the daily commuter, we find that (with the initial frequency allocation for GSM) the following interference would be perceived :-

- 1 burst lasting 2 mins on the train daily
- 1 burst lasting 2 mins at the train station every 1.5 months
- 1 burst lasting 3s on the street daily
- 1 burst in the office lasting 2 mins every month

Further to this, it can be said that the hearing aid user will be unable to use a portable digital cellular telephone. Operation of a vehicle installed telephone would however, be possible.

5. Solutions

There are things that can be done both from the mobile radio side and from the hearing aid side.

For the GSM cellular system, the following constraints can applied to minimise interference :-

- Dynamic power control to be used
- Small cells implemented where possible
- Discontinuous transmission to be used

All these aspects will ensure that the transmitter is operating for the shortest possible time and using the lowest possible transmit power.

However, this is unlikely to reduce the problem to an acceptable level. An increased immunity to RF interference is therefore required for hearing aids. Tests have shown that if the immunity is raised from the current 3 V/m to around 10 V/m then interference will be significantly reduced. These tests also indicated that this increase could be achieved with simple modification to the hearing aid design.

6. Conclusion

Extensive research has highlighted a compatibility problem between TDMA transmitters and hearing aids. These TDMA transmitters may be GSM transmitters but could be from any system using the TDMA principle. Since TDMA is being favoured for a number of future telecommunications systems, the number of TDMA mobile terminals is likely to dramatically increase in the coming years.

This problem could be dramatically reduced by applying system design constraints for the GSM system and an increased immunity from 3 V/m to 10V/m for future hearing aid devices.

It is hoped that in presenting this work to COST 219, some practical ways for improving hearing aid immunity can be found and implemented in future hearing aid designs. This would greatly benefit the hearing impaired in years to come when the number of mobile telephones has greatly increased. Such an improvement may also mean that hearing impaired people will be able use portable digital cellular telephones themselves.